ENHANCED OCEANIC SITUATIONAL AWARENESS FOR THE NORTH ATLANTIC CORRIDOR

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ABSTRACT

Air traffic control (ATC) mandated, aircraft separations over the oceans, impose a limitation on traffic capacity for a given corridor. The separations result from a lack of acceptable situational awareness over oceans where radar position updates are not available. This study considers the use of Automatic Dependent Surveillance (ADS) data transmitted over a commercial satellite communications system as an approach to provide ATC with the needed situational awareness and thusly allow for reduced aircraft separations. Traffic loading from a specific day are used as a benchmark against which to compare several approaches for coordinating data transmissions from the aircraft to the satellites.

1 INTRODUCTION

Current procedures mandate that North Atlantic oceanic air traffic maintain 60 Nautical Miles (NMi) separations [1]. On the other hand, over Continental United States (CONUS) regions, Federal Aviation Administration (FAA) requires a 5 NMi separation. The difference in separation requirements is a direct result of the lack of surveillance radar coverage. Regularly derived position information from radar allows ATC to regularly monitor aircraft positions and react quickly to any changes. The very lack of surveillance radar over oceanic regions means that ATC does not have current position information, and therefore, must maintain much stricter separation requirements.

In the CONUS case where radar coverage is nearly ubiquitous, ATC radar data is automatically received at the regional control centers. Aircraft have little if any requirement to communicate nominal position information to ATC. Over the oceans, ATC must use High Frequency (HF) radio links to request position updates from each aircraft. HF radio has limitations in clarity and reliability. HF radio does not mitigate the burden on ATC to obtain current position knowledge and therefore, the separation requirements cannot be relaxed.

This study explores the technical aspects of a satellite-based approach to oceanic aircraft surveillance that would provide ATC with more timely and reliable position information. This then may provide the means for reducing the current separation requirements and increasing oceanic corridor capacity. Specifically, by all aircraft in the North Atlantic Corridor transmitting their ADS data to an Aeronautical Mobile Satellite System (AMSS) and the AMSS relaying that data to ATC, then the required surveillance information would be available to support reduced separations. The potential AMSS that is considered in this study is a Low-Earth orbiting (LEO) satellite system, but another AMSS in geostationary orbit can fulfill the role as well. The reason for choosing one particular AMSS is that it provides us needed communication systems data for both the space and air segments.

It is noted that this study merely intends to investigate the broad technical aspects of ADS over satellite; that it is cognizant of but is not applying in this study the numerous, strict procedures imposed on oceanic crossing aircraft, in order to obtain a high level indication of what can be achieved just considering communications.

[7] Lemme, Peter W., Glenister, Simon M., Miller, Alan W., "Iridium Aeronautical Satellite Communications," IEEE, 1998.

[8] Hubbel, Yvette C., "A Comparison of the IRIDIUM and AMPS Systems," IEEE Network, March/April 1997.

[9] Eurocontrol, "Eurocontrol Standard Document for Surveillance Data Exchange Part 12 Transmission of ADS-B Messages," <www.eurocontrol.int/asterix/documents/p12ed010.pdf>, March 2000.

Oceanic Situational Awareness for the North Atlantic Corridor

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Oceanic CNS Issues

– No radar/communications infrastructure

– Large, mandatory, procedural separations

– Projected increase in traffic load

– Limited expansion capacity

Oceanic CNS Amelioration

– Provide CNS “infrastructure” via AMSS

– Deliver timely surveillance information

– Shrink mandatory separations based on improved CNS

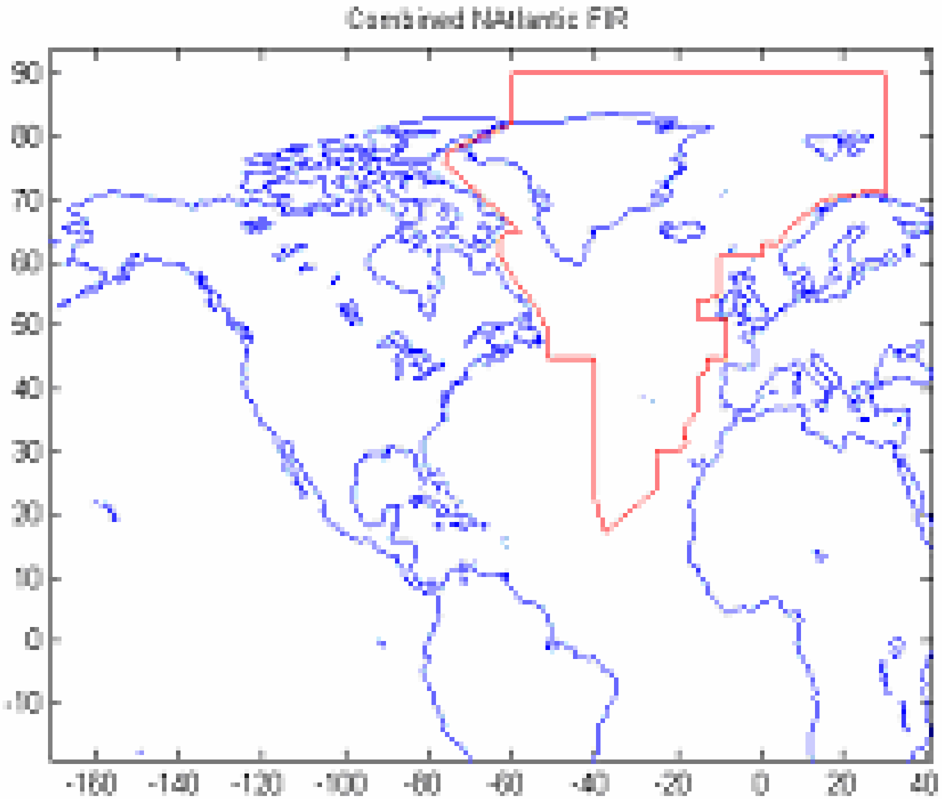
– Accommodate traffic expansion

QUESTION:

How do we model this?

Oceanic Situational Awareness for the North Atlantic Corridor

North Atlantic Flight Information Region



Oceanic Situational Awareness for the North Atlantic Corridor

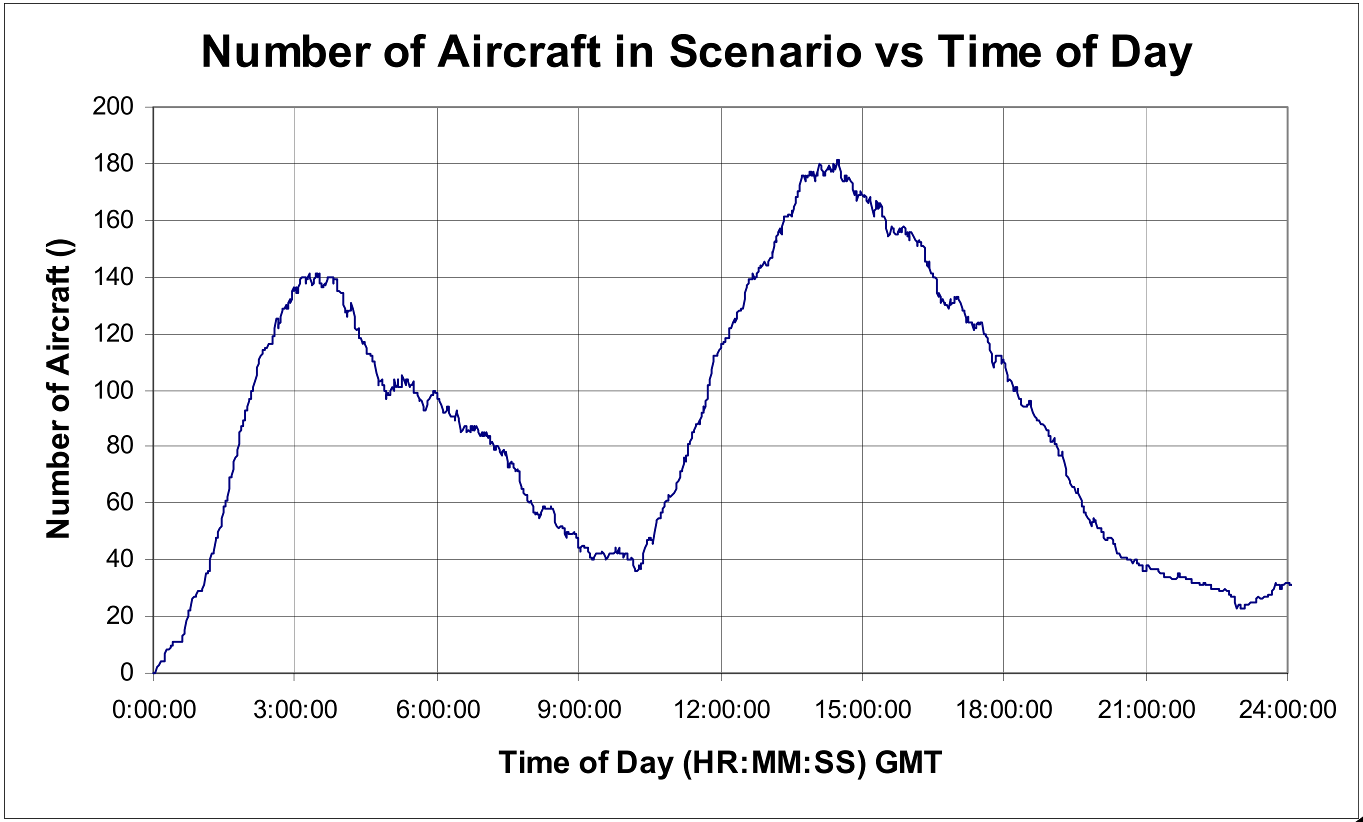
West Bound Flights in Gold

East Bound Flights in Purple

Click here to play movie

Oceanic Situational Awareness for the North Atlantic Corridor

FAA flight data from July 18, 2001



Maximum Geometrical Corridor Capacity

– 60 NMi Separation	314
– 45 NMi Separation	546
– 30 NMi Separation	1197
– 15 NMi Separation	4674

AMSS Link Budget Assumptions (Iridium Like)

- 8° minimum elevation angle
- 42.43 W average transmitter power
- 3dB of additional losses
- QPSK modulation
- 1e-9 BER
- Zenith Distance of 780 km
- Horizon Distance of 2460 km
- Frequency of 1.623 GHz
- Satellite G/T of -16.315 dB/K
- Burst Data Rate of 50 kbps

System Refresh Period

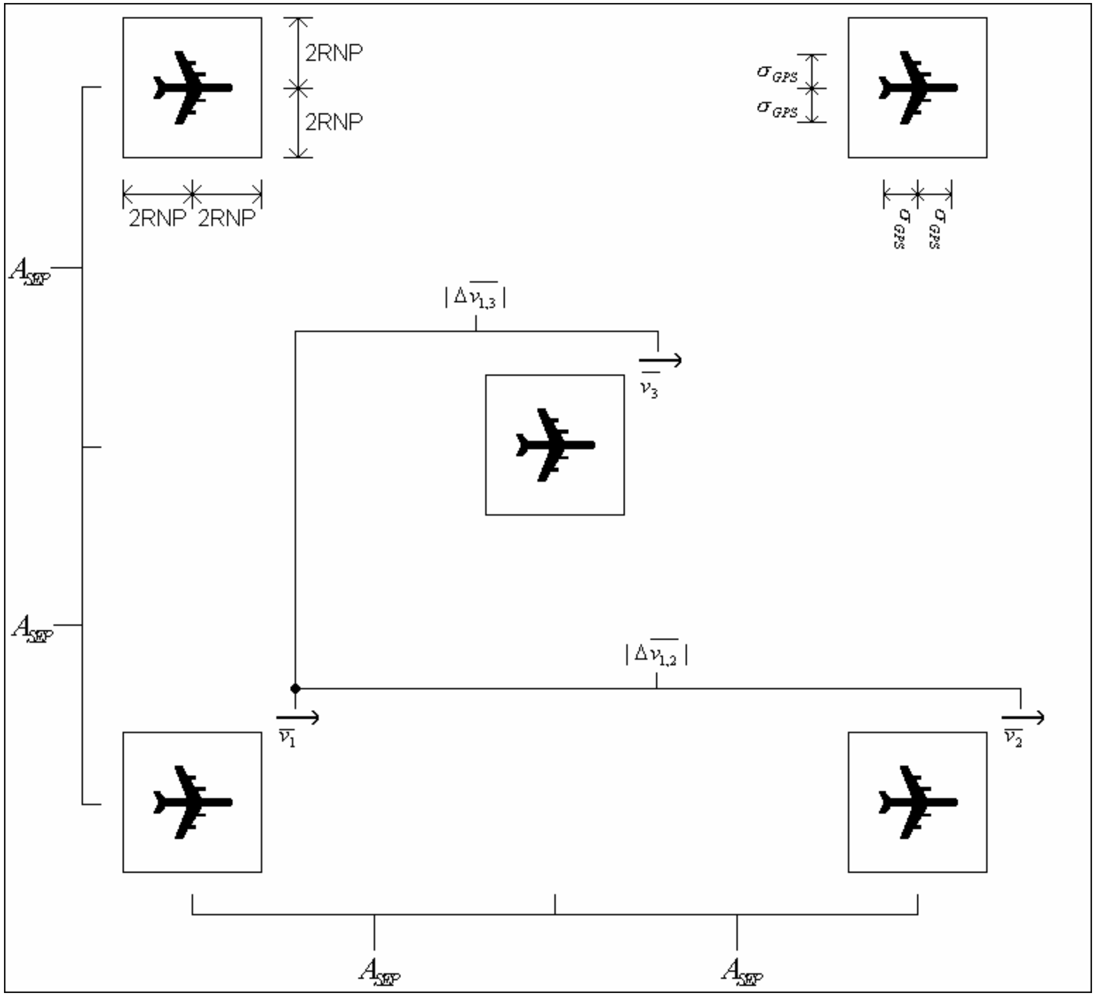
- The amount of time that is required for all of the aircraft in the corridor to transmit their messages, one time.

- For aircraft separation reductions to occur safely, all aircraft in the corridor must transmit their position information within the maximum system refresh period.

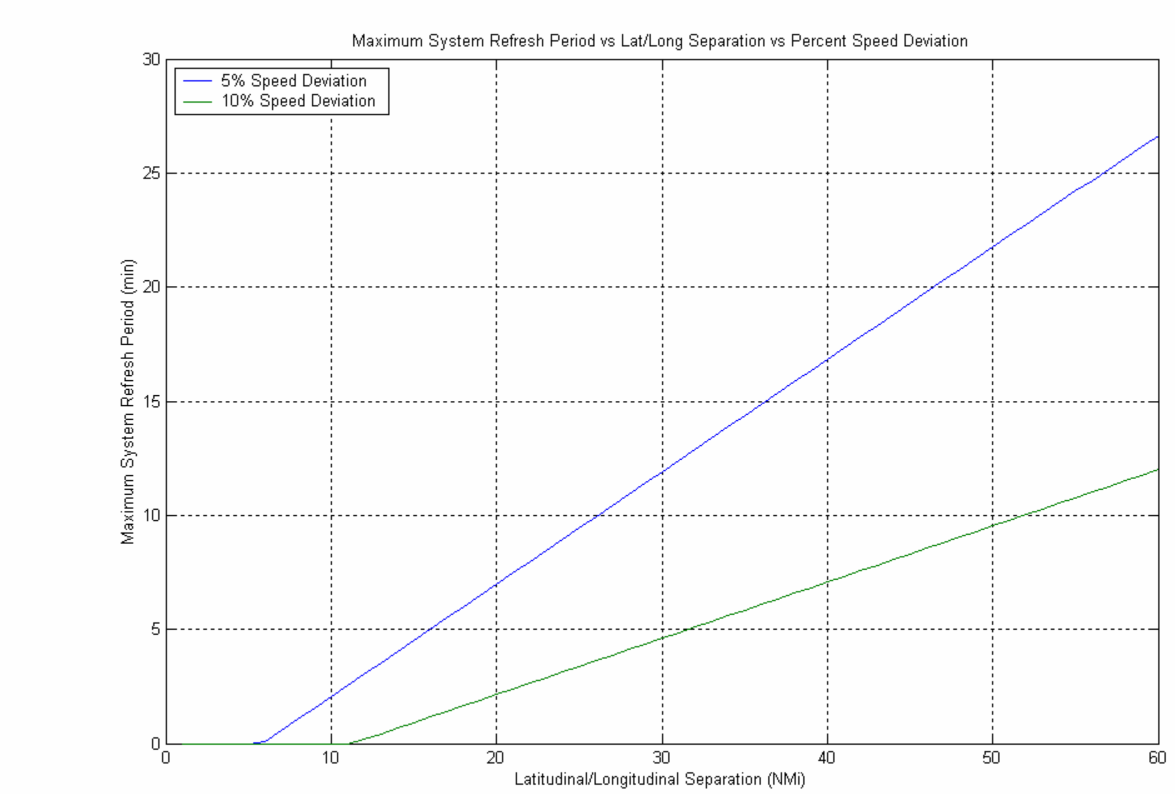
System Refresh Period Factors

- Required Navigation Performance (RNP) to aircraft separation ratio
- Latency (delay from transmission to reception) of position message from aircraft to ATC
- Latency of warning message from ATC to aircraft
- Pilot and aircraft response delay from warning message reception at aircraft to aircraft separation stabilization
- Average aircraft speed
- Speed deviation between aircraft
- Standard deviation for GPS reported position
- Aircraft are not flying on the same path in opposite directions
- Aircraft will not arbitrarily change altitudes

Oceanic Situational Awareness for the North Atlantic Corridor



Maximum System Refresh Period vs. Separation and Speed Deviation



5 Percent Speed Deviation

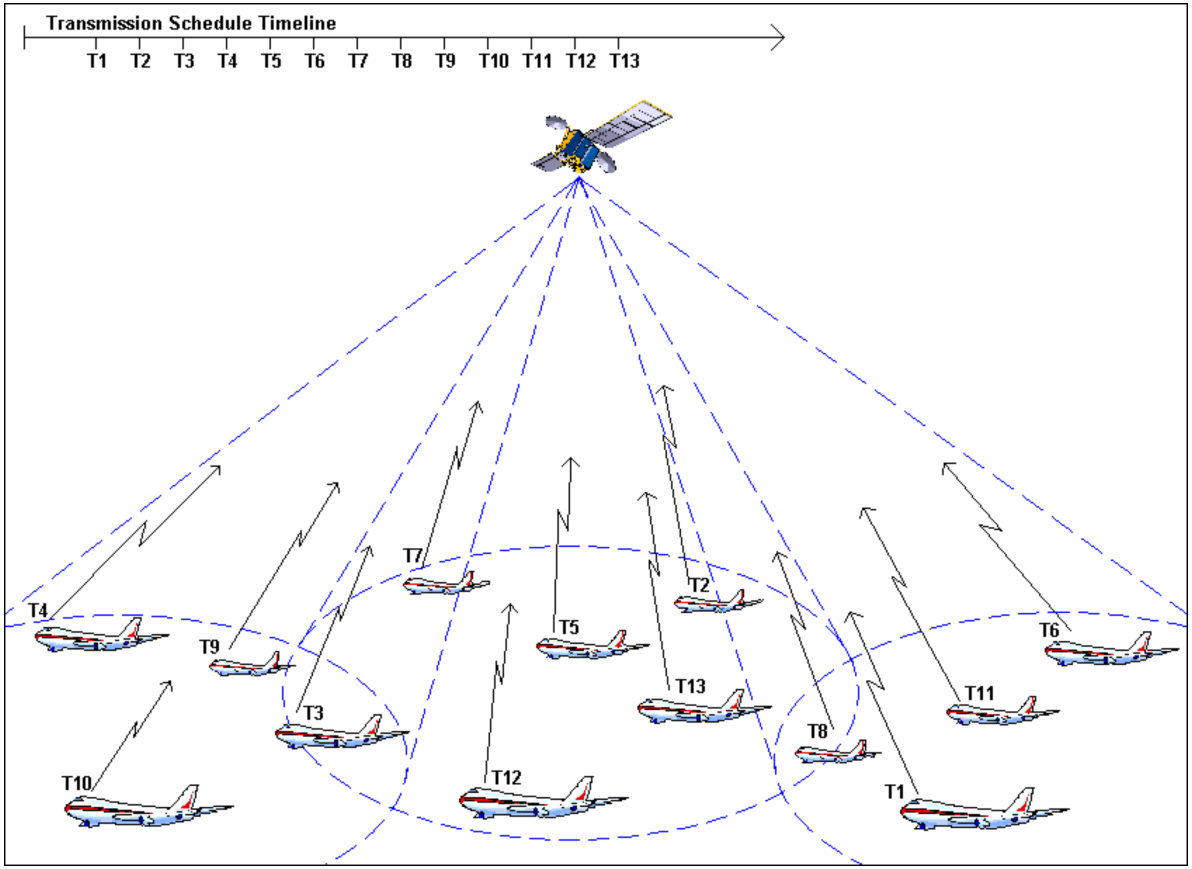
10 Percent Speed Deviation

Transmission Methods

- Method 1 – Single Aircraft Transmission at a Time
  - Case 1 – Own Data Transmission
  - Case 2 – Vicinity Data Transmission
- Method 2 – Maximum Aircraft Transmission at a Time
  - Case 1 – Own Data Transmission
  - Case 2 – Vicinity Data Transmission

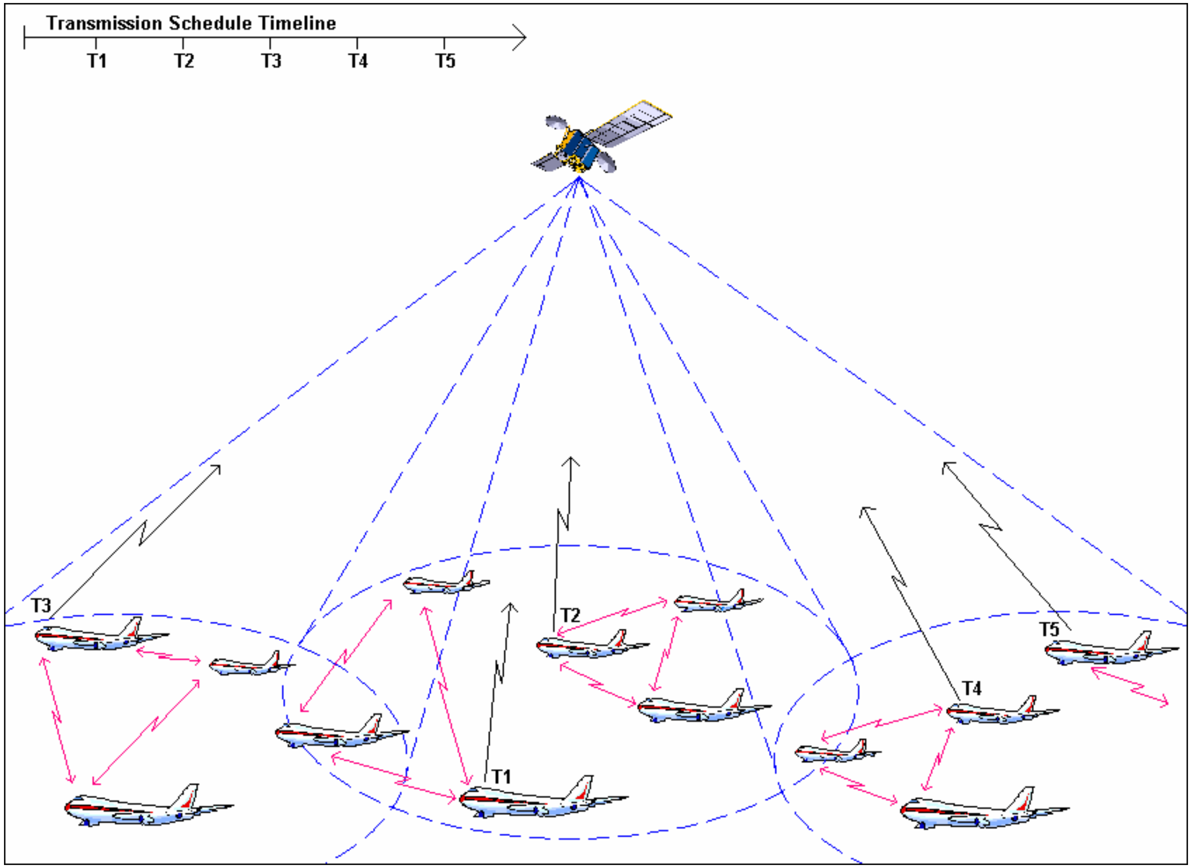
Oceanic Situational Awareness for the North Atlantic Corridor

Method 1 – Case 1

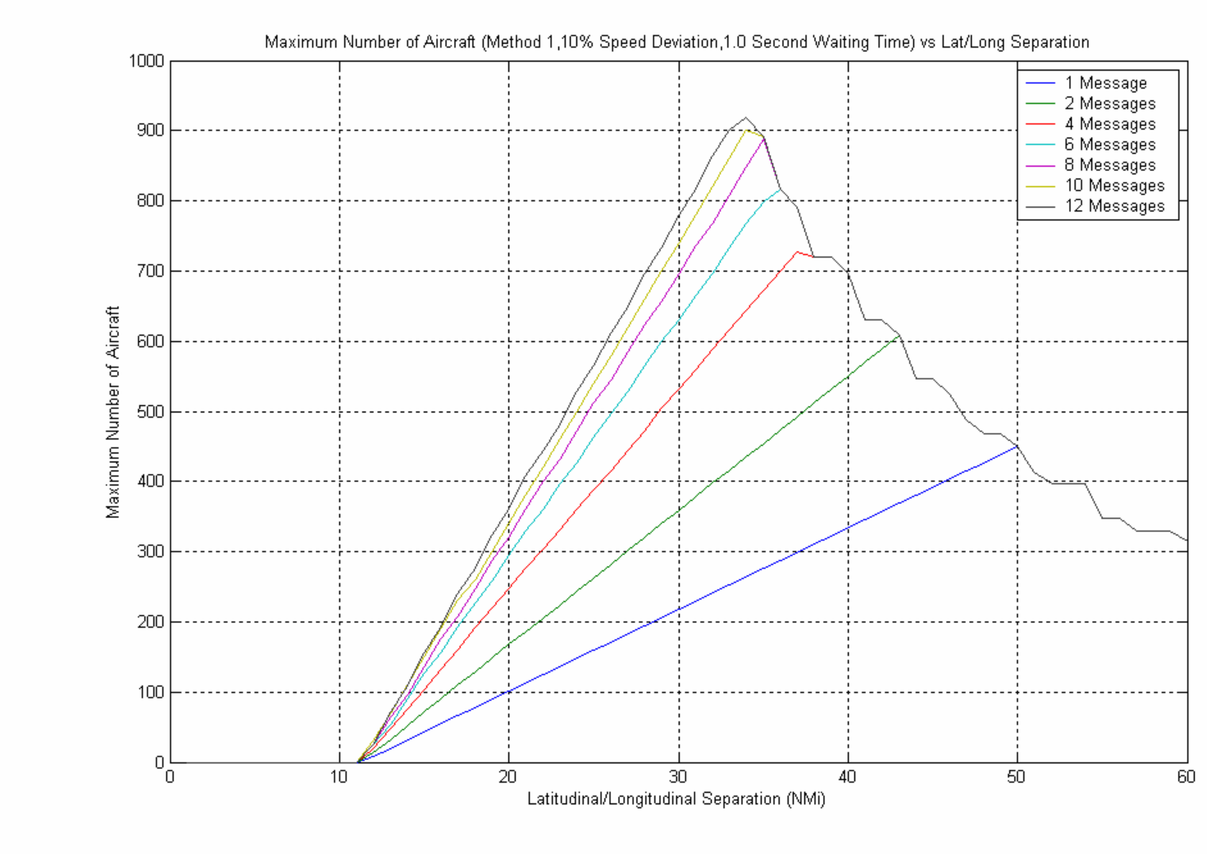


Oceanic Situational Awareness for the North Atlantic Corridor

Method 1 – Case 2



Maximum Number of Aircraft – Method 1



Maximum Number of Aircraft – Method 1

Messages per Transmission	60 NMi	45 NMi	30 NMi	15 NMi
1	314	392	218	43
2	314	546	358	72
4	314	546	532	104
6	314	546	630	126
8	314	546	696	136
10	314	546	740	150
12	314	546	780	156

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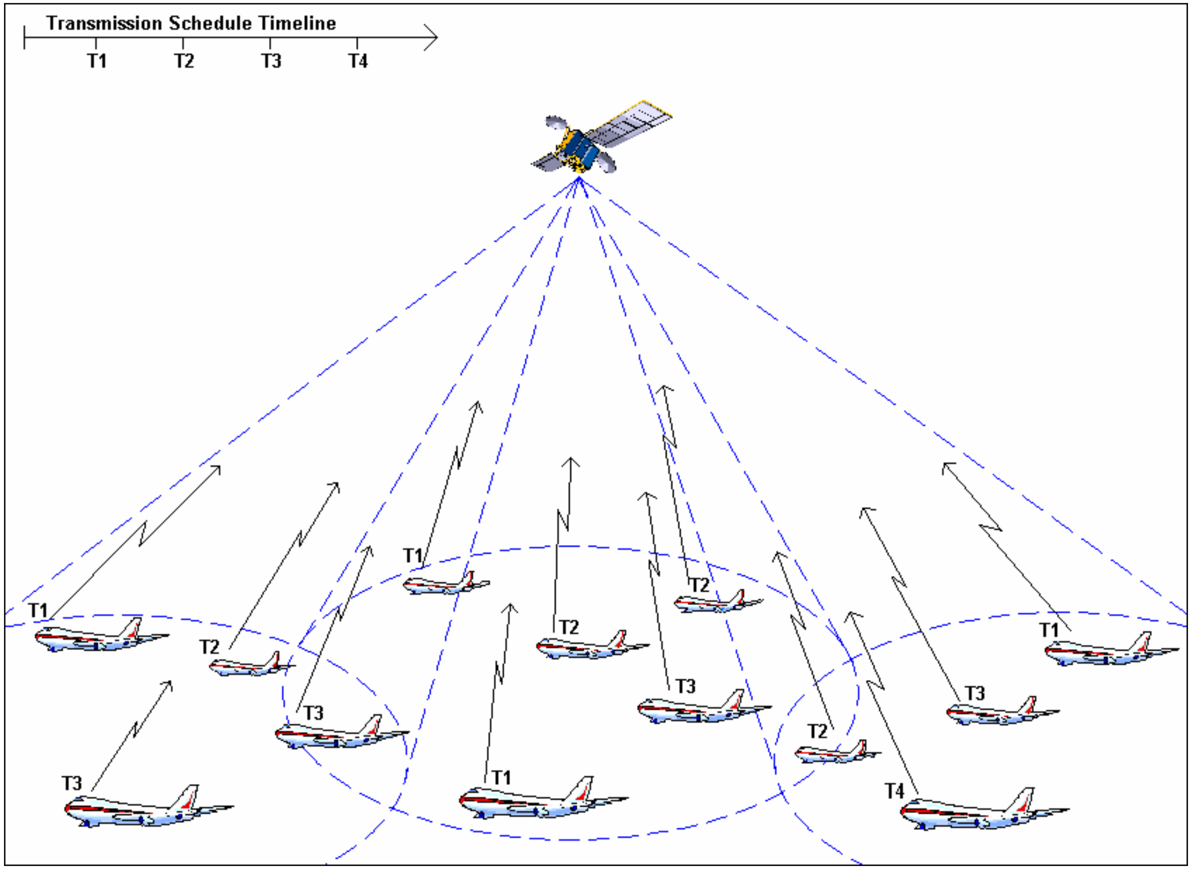
Method 2 – Case 1



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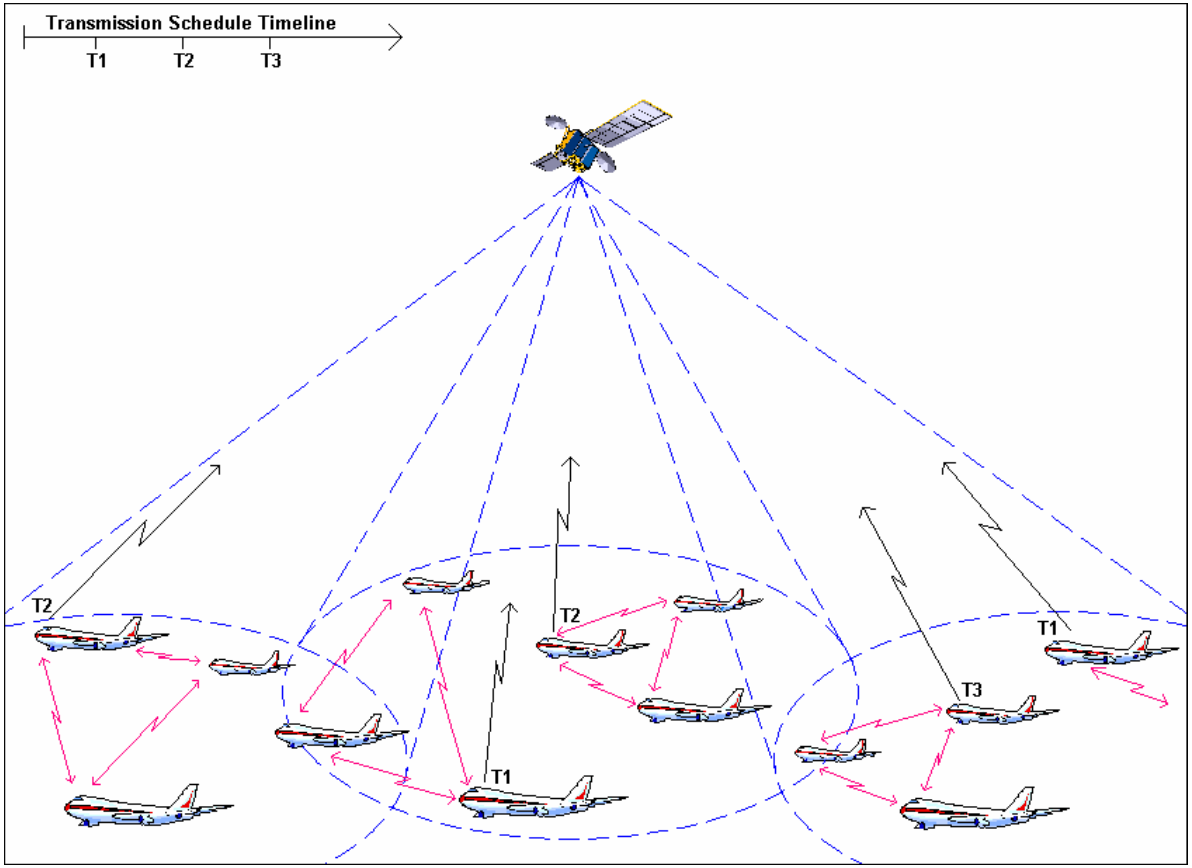
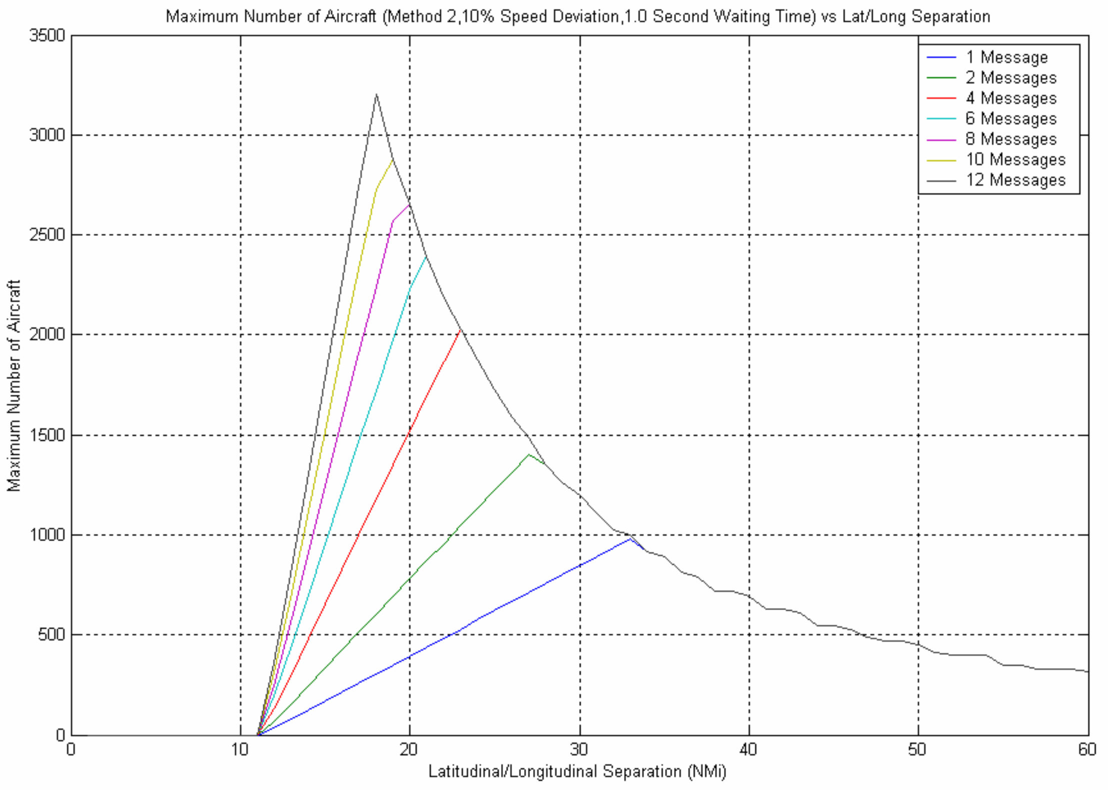
Method 2 – Case 2



Maximum Number of Aircraft – Method 2



Maximum Number of Aircraft – Method 2

Messages per Transmission	60 NMi	45 NMi	30 NMi	15 NMi
1	314	546	846	169
2	314	546	1197	334
4	314	546	1197	652
6	314	546	1197	954
8	314	546	1197	1248
10	314	546	1197	1520
12	314	546	1197	1788

Summary

- On a theoretical level:
  - Several AMSS/ADS methods show potential
  - Communications capacity can meet requirements
  - Sufficient surveillance data can be provided
- Taking all that into account:
  - Reduced separations might be considered, but level of separation will depend strongly on procedures